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Intraoperative colonic pulse oximetry in left-sided colorectal surgery: can it predict anastomotic leak?

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Abstract

Background An anastomotic leak is a fairly common and a potentially lethal complication in colorectal surgery. Objective methods to assess the viability and blood circulation of the anastomosis could help in preventing leaks. Intraoperative pulse oximetry is a cheap, easy to use, fast, and readily available method to assess tissue viability. Our aim was to study whether intraoperative pulse oximetry can predict the development of an anastomotic leak.

Methods The study was a prospective single-arm study conducted between the years 2005 and 2011 in Helsinki University Hospital. Patient material consisted of 422 patients undergoing elective left-sided colorectal surgery. The patients were operated by one of the three surgeons. All of the operations were partial or total resections of the left side of the colon with a colorectal anastomosis. The intraoperative colonic oxygen saturation was measured with pulse oximetry from the colonic wall, and the values were analyzed with respect to post-operative complications.

Results 2.3 times more operated anastomotic leaks occurred when the colonic StO₂ was ≤90% (11/129 vs 11/293). The mean colonic StO₂ was 91.1 in patients who developed an operated anastomotic leak and 93.0 in patients who did not. With logistic regression analysis, the risk of operated anastomotic leak was 4.2 times higher with StO₂ values ≤90%.

Conclusions Low intraoperative colonic StO₂ values are associated with the occurrence of anastomotic leak. Despite its handicaps, the method seems to be useful in assessing anastomotic viability.

Keywords Anastomotic leak · Colorectal surgery · Oximetry

Introduction

A leak in a colorectal anastomosis increases morbidity, mortality, risk of a poor oncological outcome, and length of hospital stay [1–3]. Despite its pivotal role as a complication, the definitive consensus of the definition of anastomotic leak (AL) is still lacking [4]. Depending on the patient material,

hospital, site of anastomosis, and definition, the rate of AL varies between 1 and 30% although 3–6% is often quoted as an acceptable overall leak rate [5].

Many studies can be found about the risk factors for AL. The results are inconclusive, but some risk factors come up in most of the studies: male gender, chronic steroid use, ASA (American Society of Anesthesiologists) classification, intraoperative blood loss, obesity, smoking, alcohol abuse, long operation time, low anastomose, and neoadjuvant radiation therapy [2, 5–7].

Assessment of the tissue viability is made by the operating surgeon, mostly based on tissue color and the amount of bleeding. Measuring tissue blood flow/oxygenation by means of laser Doppler flowmetry, hemoglobin oxygenation spectroscopy, etc. [8–10] has shown promising results in detecting anastomoses susceptible to leak. These methods, however, require special equipment and have not been adequately studied within larger patient series. Perioperative supplemental

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oxygen administration has also been speculated to decrease the risk of AL [11]. The main goal of our study was to determine whether anastomotic tissue oxygenation measured by a cheap and commonly available pulse oximetry probe correlates with anastomotic leak.

Materials and methods

The patient material of the study was identified from all of the patients who underwent elective left-sided colorectal surgery with colorectal anastomosis (sigmoid colectomy, left hemicolectomy, or anterior resection) by one of the three surgeons (M.C-H, O.K, T.S). 92.4% of the operations were laparoscopic. The operations were done in Helsinki University Hospital between the years 2005 and 2011.

Clinical data was collected from preoperative anesthesia questionnaires, perioperative anesthesia forms, and patients' medical records. The acquisition of this data was approved by our institutional review board. All of the patients were treated by the local standard of care.

The colonic hemoglobin oxygen saturation levels (StO₂) were measured after the division of the mesentery at the place where the bowel was planned to be divided. Equipment used for measuring consisted of a Datex Ohmeda S/5 (GE Healthcare Finland, Helsinki) monitor and a connected pulse oximetry probe. The probe has a light source that emits red and infrared light (660 and 910 nm) and a light sensor. The arterial hemoglobin oxygen saturation level is calculated from the pulsative part of the light signal by analyzing the amount of light absorbed by hemoglobin.

Sixty-eight patients did not have a recorded colonic StO₂ value; a total of 422 patients with a recorded pulse oximetry value were included in the statistical analyses.

The anastomotic leaks were categorized in two groups: major leaks requiring re-operation (Clavien-Dindo classification grade IIIb and up) and confined, smaller leaks treated conservatively (grade I–IIIa) [12].

Re-operated major ALs were chosen as the main end point. Differences between patients with operated AL and other patients were analyzed using chi-square test for independence for categorical variables and Mann-Whitney *U* test for continuous variables. A logistic regression analysis was performed to assess the variables that had a significant association with operated AL.

Associations between measured StO₂ values and other variables were examined using Mann-Whitney *U* test for variables with two categories and Kruskal-Wallis test for variables with three or more categories. Continuous variables were first analyzed using Spearman's rho and correlating ($p < 0.1$) variables were then binned and analyzed.

The data was analyzed using IBM SPSS statistics software version 22 (IBM Corp. Armonk, NY, USA).

Results

The amount of AL complications was 31/422 (7%). Nine of these were small leaks that were treated with antibiotics and/or drainage, whereas 22/422 (5%) had an AL that required re-operation.

AL had significant association with eight variables. Males were at a higher risk (7.8 vs 3.3%), $p = 0.041$. The risk of developing an AL depended on the type of primary operation done; the risk was small with sigmoid colectomies (2.3%) compared to left hemicolectomies (11.9%) and anterior resections (15.2%), $p = 0.000$. Converting the operation (14.8 vs 4.4%), $p = 0.020$, long operation time (159.5 vs 134.1 min), $p = 0.016$, and heavy bleeding (325.7 vs 162.9 ml), $p = 0.010$, was also an independent risk factor. Patients with no long-term illnesses had a smaller AL rate (1.7 vs 6.5%), $p = 0.049$.

The main variable of interest, colonic StO₂, was lower in patients who developed an AL (91.1 vs 93.0) like the study hypothesis suggests; however, this difference was not significant, $p = 0.292$. The rest of the variables (age, BMI, ASA class, indication of operation, TN class, oxygen concentration of inhalation gas, previous operations, smoking status) did not have a significant association with AL.

When the patients were divided into groups according to the StO₂ value, AL occurred at a higher rate among the groups with lower StO₂ value. With StO₂ 90% defined as the cut-off point, the risk of AL was significantly higher in patients who had StO₂ ≤ 90 , $p = 0.042$. The results are presented in Fig. 1.

The association of the StO₂ values and other variables was also examined and significant association with StO₂ was found with five variables:

Patients operated due to a tumor had lower StO₂ (cancer 91.8, benign tumor 91.8) than other patient groups (diverticulosis 93.4, volvulus 96.2, other 95.3), $p = 0.047$. Older patients had lower StO₂, when patients were grouped in five groups with 15 year intervals, $p = 0.04$. The mean StO₂ was

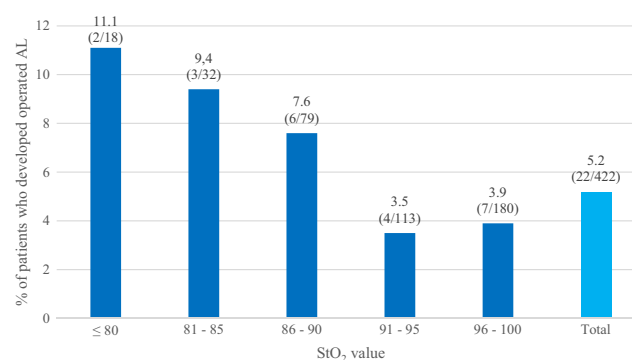


Fig. 1 The patients are divided into groups according to the StO₂ value. The bars represent the percentage of patients within the StO₂ range who developed an operated AL. Chi-square test for independence gives a p value of 0.334 for the StO₂ groups above. If the groups are narrowed to two, StO₂ ≤ 90 and StO₂ > 90 , we get a p value of 0.042 and a risk ratio of 2.3 for developing an operated AL if StO₂ is $\leq 90\%$

94.6 with patients under 35 years and 87.8 with patients over 80. Lower StO₂ levels were found in patients with diabetes (91.1 vs 93.0), $p = 0.03$, hypertension (92.2 vs 93.3), $p = 0.046$, and dyslipidemia (91.5 vs 93.2), $p = 0.01$.

The variables with a significant association with AL in the logistic regression analysis were the type of operation, smoking, conversion, and colonic StO₂. The odds ratio (OR) for developing an AL requiring re-operation was 0.24 when colonic StO₂ was $> 90\%$, and the risk for a leak was 4.2 times higher when StO₂ was $\leq 90\%$, $p = 0.008$. The OR for AL was 3.432 for smoking, $p = 0.025$, 10.538 for left hemicolectomy, $p = 0.000$, 10.561 for anterior resection, $p = 0.004$ (vs sigmoid colectomy), 2.995 for conversion, $p = 0.147$, and 14.422 if open from beginning, $p = 0.031$ (vs not converted). The same logistic regression model was also run with all AL complications as the end point. In this analysis, conversion was not significant; otherwise, the results were similar.

Sixty-eight (13.9%) patients had to be omitted because StO₂ value was not available. Because of this, 29% (9/31) of the operated ALs were not included in the analyses. Differences between the excluded and the included patient groups were analyzed using chi-square test for independence for categorical variables and Mann-Whitney U test for continuous variables. Significant differences were found in ten variables. Excluded patients were older (63.6 vs 59.9 years) and had a higher ASA class, the ratio of operations due to tumor was higher, the ratio of anterior resections was higher, operations lasted longer (152.4 vs 135.4 min), intraoperative blood loss was higher (395.6 vs 172.4 ml), the length of hospital stay was longer (8.1 vs 4.8 days), the rate of anastomotic leak as well as other complications was higher, and the rate of operations converted was higher.

Discussion

Colonic oxygen saturation is significantly associated with the occurrence of AL. Re-operated ALs occurred 2.3 times more often when the colonic StO₂ was $\leq 90\%$. Other significant risk factors for AL were the type of operation performed, operation length and blood loss, conversion, male sex, and having long-term illnesses. In the logistic regression, the type of operation, smoking, conversion, and colonic StO₂ were significant risk factors for AL. Low anastomosis (type of operation performed), operation length, intraoperative blood loss, male sex, and smoking have been found as risk factors for AL in previous studies as well [2, 5–7].

AL occurred more often in patients operated due to a tumor (AL rate 8.5% with cancer, 7.7% with benign tumor, and 3.3% with diverticulosis) although this difference was not significant, $p = 0.116$. The difference could be explained by the more radical transection of arteries when operating tumors. This is also likely to be the reason for lower StO₂ values in this group.

Patients of whom the StO₂ was not recorded were older, and the operations were more challenging (longer operation time, higher blood loss, cancer vs diverticulosis, anterior resection vs sigmoid colectomy, more conversions). This explains in part why the StO₂ was not measured (the surgeon was too busy with the operation).

The disadvantage of pulse oximetry is that it measures the oxygenated hemoglobin rate that travels in the tissue during a pulse and therefore measures the hemoglobin oxygenation rate of arterial blood. It does not fully reflect the local tissue oxygenation. Even with well-oxygenated arterial blood, the blood flow to the tissue might be insufficient.

In conclusion, measuring colonic StO₂ does seem to give information on the viability of the anastomosis. This method is cheap and easy to use and despite its disadvantages, low StO₂ levels do indicate a higher risk for AL.

Compliance with ethical standards The acquisition of this data was approved by our institutional review board. All of the patients were treated by the local standard of care.

Conflict of interest The authors declare that they have no conflict of interest.

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